

METHOD AND APPARATUS FOR TRANSLATING COMPUTER PROGRAMS

FIELD OF THE INVENTION

The present invention relates to the translation of natural language portions of computer programs. In particular, the present invention relates to the translation of 5 natural language text into one or more target natural languages, concurrently with the development of the source program.

BACKGROUND OF THE INVENTION

Computer programs are increasingly important to the efficient operation of business enterprises throughout the world. For business enterprises having operations 10 located in various parts of the world, it is desirable to provide software having natural language text that has been translated into languages that are local to the area in which the end user is located. Accordingly, it is necessary to translate natural language portions of computer software into languages other than the language used by the original programmers.

15 For computer programs intended for use in many different areas around the world, a very large number of natural language translations are necessary. Accordingly, significant man hours must be expended in order to prepare such translations.

In a typical software development process, a version of a computer program is written using an original or source natural language (e.g., English). The source language 20 program is then refined until it is deemed ready for commercial use, at which point the software product is finalized or mastered. Translation of natural language portions of the original program into other languages (e.g., German and Spanish) may then be

undertaken after mastering of the original program. Because translation does not begin until the original program has been finalized, delays in bringing versions of the product to market in languages other than the source language can be significant.

In addition to delays in bringing translated programs to market, traditional
5 approaches to preparing translations have been difficult to implement. This is because computer programs typically draw text from many different sources. Therefore, ensuring that all portions of natural language text associated with a computer program have been translated into a target language is an arduous and time consuming process.

In addition to difficulties ensuring that all of the natural language text has been
10 translated, traditional methods for preparing translated computer programs have often resulted in inaccurate translations. This is because the context in which portions of natural language text are used in an application are often unavailable to the translator. As a result, the translation entered by a translator may be inappropriate when the translated text is seen in the context of its use in the computer program. In particular, the traditional
15 method of considering natural language text as it appears in source tables, rather than in the context in which such language text will appear to the end user, may result in unsatisfactory translations.

Therefore, it would be highly desirable to provide a new system for preparing
natural language translations of computer programs. In particular, it would be desirable
20 to provide a system that allowed translations of natural language text contained in a computer program to be prepared concurrently with development of the original or source program. In addition, it would be desirable to provide such a system that allowed

changes to the source text and changes to the translated text to be tracked, to avoid duplication of effort and to ensure that the translated portions of text accurately reflect the final version of text in the source program. Furthermore, it would be desirable to provide such a system that allowed a translator to view the context in which portions of natural language text appear in the computer program.

SUMMARY OF THE INVENTION

In accordance with the present invention, a system for translating natural language portions of computer programs is provided. The present invention allows translations of natural language text included in a source computer program to be performed, even while development of the source computer program is on-going. Furthermore, translations of text in a source computer program that become obsolete can be tracked, and any such translation may be beneficially applied in preparing a new or updated translation. The present invention also provides metrics regarding the translations of source text to assist translators in managing work flows.

15 According to the present invention, changes to textual portions of a source computer program written in a source language are made in a production copy of the source computer program. The production copy is periodically compared to a comparison copy. During such a comparison (or delta process), one or more status tables are updated to reflect the most recent changes made to records containing text in the

20 source computer program. A status table is maintained for each target language for which a translation of the source computer program is being prepared. The status table or tables contains information regarding whether or when records containing the most recent

translations of portions of the source computer program's natural language text have been translated into the particular target language. In particular, the status table or tables indicates whether a portion of natural language text has been translated from the source language, and whether changes have occurred with respect to records that were 5 previously translated. Translated text is stored as part of a target version of the computer program. In general, a different target computer program is prepared for each translation of the source program into a target language.

According to an embodiment of the present invention, the status table is updated periodically, so that translators can respond to changes to or additions of natural language 10 text records contained in the source computer program. As natural language text records are translated, updates are made to the status table or tables. Accordingly, translators can track how much natural language text remains to be translated from the source program. In addition, the status table or tables may be used to store information regarding the level 15 of review received by translated natural language text records, to facilitate the preparation of accurate translations.

In accordance with yet another embodiment of the present invention, revisions to or additions of records containing text in the source computer program are detected when the periodic comparison operation is performed. The status table may then be updated to notify translators that modifications are necessary. When selecting a modified record or 20 portion of text for translation, the translator may be presented with the translation of the previous version of the text, to assist the translator in preparing the new version. In

addition, the source text may be presented to the translator in a box adjacent to an edit box for entering or editing the translated version of the text (*i.e.* the target text).

In accordance with still another embodiment of the present invention, a translator may view a portion of text as that text would appear to a user running the computer program. This capability may be provided for both source text and target text. In 5 addition, both the source version and target version of the text may be viewed by a translator in the context of how they will appear to users of the respective computer programs, to assist the translator in preparing an accurate translation.

In accordance with still another embodiment of the present invention, a translator 10 may select a portion of text for translation or re-translation. Upon selection of a portion of text, the translator is presented with that portion of text in the source language, and with any previously prepared translation or partial translation of that text into the target language that the translator is working with, if available. The translator is additionally provided with an edit box to allow the translator to enter a translated version of the text, 15 or to edit a previous translation of that text. According to still another embodiment of the present invention, the translation of text may be automated by providing suggested translations. Such suggested translations may be obtained from previous translations of identical or similar portions of text that have already been prepared in connection with the computer program. According to yet another embodiment of the present invention, 20 spell checking capabilities may be provided for the translated text.

An apparatus for providing a system in accordance with the present invention may comprise a processor and software operable on the processor to enable the creation of

status records, and the retrieval of records containing source text and corresponding translated text related to a computer program. The source computer program from which text to be translated is obtained, and the portions of text translated into a target language, are maintained on one or more storage devices. In addition, status tables containing 5 information related to the history of changes and additions to the source text and to translations of the source text are also maintained on one or more storage devices. The apparatus may comprise a number of interconnected computing devices.

Based on the foregoing summary, a number of salient features of the present invention are readily discerned. A system and a method for facilitating the translation of 10 natural language text portions of computer programs into one or more target languages is provided. According to the present invention, a status table comprising a record of changes made to the source text is maintained for each target language, to allow a thorough translation of the source program into those target languages. In particular, the status table or tables comprise a record of translated text records, to provide an indication 15 of records containing text remaining to be translated, and of records containing text that have been updated in the source program and thus require retranslation. Furthermore, the present invention allows the translator to view the source text concurrently with the translated text, and additionally allows the translator to view the source text and the translated text in the context of the computer program, as that text will be seen by the end 20 user. In addition, the present invention automates the translation process, facilitating the preparation of accurate translations in a timely manner.

Additional advantages of the present invention will become readily apparent from the following discussion, particularly when taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

5 **Fig. 1** is a block diagram of a computer system in accordance with an embodiment of the present invention;

Fig. 2 is a block diagram of a general purpose computer for use in connection with the system of **Fig. 1**;

10 **Fig. 3A** is a block diagram depicting the development of a source computer program and translations of that source computer program into various target languages;

Fig. 3B illustrates an arrangement of data in accordance with an embodiment of the present invention;

Fig. 4 illustrates the relationship between various records and tables utilized in connection with an embodiment of the present invention;

15 **Fig. 5** is a flow chart illustrating the development of translated computer programs in accordance with an embodiment of the present invention;

Fig. 6 is a block diagram depicting certain functional aspects of a translation application in accordance with an embodiment of the present invention;

20 **Fig. 7** is a flow chart illustrating a translation process in accordance with an embodiment of the present invention;

Figs. 8-38 are screen shots of window displays illustrating translation-related operations using a translation application in accordance with an embodiment of the present invention.

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DETAILED DESCRIPTION

With reference now to Fig. 1, a computer system 100 in accordance with an embodiment of the present invention is illustrated. In general, the computer system 100 includes at least a first server computer 104, and a plurality of client computers 108. The server computer 104 and the client computers 108 are interconnected to one another by a computer network 112. In general, the computer system 100 may include a number of server computers 104, and a lesser or greater number of client computers 108. In addition, the present invention may be implemented using a single computer (e.g., a computer 104 or 108).

In the computer system 100 illustrated in Fig. 1, the server computer 104 is shown as providing storage for a database 116. The database 116 may generally include tables and records used in connection with the development of a source computer program and with translations of the source computer program into one or more target languages. The first client computer 108a is shown as providing the resources necessary for operating a development application 120. In general, the development application 120 facilitates the development and eventual mastering of the source computer program. The second client computer 108b is shown in Fig. 1 as providing resources required for operation of a translation tools system 122a, including a translation application 124a. As will be

described in greater detail below, the translation tools system **122** and the translation application **124a** facilitate the development of translations of the source computer program into one or more target languages. As illustrated in Fig. 1, additional copies of the translation tools system **122** and translation application **124** may be run on other client computers **108**. For example, a second copy of the translation tools system **122b** and the translation application **124b** may be operated on a third client computer **108c**.

The first 124a and second 124b copies of the translation application may be operated concurrently with respect to the translation of the source computer program into one or more target languages.

10 With reference now to Fig. 2, a typical computer 104, 108 in accordance with an embodiment of the present invention is illustrated. In general, the computer 104, 108 includes a central processing unit (CPU) 202 connected by a bus 204 to a processing storage or memory device 206, for example RAM, and to a program/data storage or memory device 208, for example one or more hard disk drives. The computers 104, 108
15 may be conventional personal computers, work station machines, mid-range computer platforms or large system computer platforms, and use conventional software operating environments depending on the available hardware platform. For example, the OS/400 operating system from IBM Corporation of Armonk, New York may be used with an AS/400 mid range computer also from IBM Corporation; the HP-UX operating system
20 from Hewlett Packard Corporation of Palo Alto, California may be used with an HP-9000 mid range computer also from Hewlett Packard Corporation; or the WINDOWS NT SERVER operating system from Microsoft Corporation of Redmond, Washington may

be used with a personal type computer. The computers **104, 108** may also operate on other conventional software operating environments such as Windows 98, Windows 2000, Windows NT or Windows ME, all from Microsoft Corporation; UNIX, from X/Open Company Limited; or SOLARIS, from Sun Microsystems, Inc. of Palo Alto, 5 California operating environments.

The CPU **202** may be a conventional, commercially available processor such as a PENTIUM processor from Intel Corporation of Santa Clara, California, or SPARC processor from Sun Microsystems, Inc. of Mountain View, California. It should be appreciated that the computers **104, 108** may be of differing configurations and use 10 different operating systems in communication with one another.

A user input interface **210**, connected to the bus **204**, is provided to enable users to input data via a pointing device **212**, such as a mouse, and via a keyboard device **214**. To provide a visual display, the computer **104, 108** also includes a display device **218** connected to the bus **204** through a display adaptor **216**.

15 An input/output (I/O) interface **220** may be connected to the bus **204** to permit a peripheral device **222** to interface with the computer **104, 108**. The peripheral device **222** may include a disk drive for reading and or writing electronic information to computer useable storage medium, such as a magnetic disk **224**. Other peripheral devices, including tape drives and compact disk drives, can also be incorporated into the computer 20 **104, 108**.

A network interface **226** is connected to the bus **204** to enable the computer **104, 108** to access the network **112** (Fig. 1). The network **112** may be a conventional logical

network, such as a local area network (LAN), or wide area network (WAN), and is implemented using commercially available network hardware and software. In addition, it should be appreciated that the computer network 112 may comprise a plurality of different networks 112, and may include the Internet, or a private intranet.

5 The inventors of the present invention have recognized that the timely translation of natural language text contained in a source computer program from a source language into one or more target languages is facilitated if translations of records containing natural language text from the source language are prepared while the source program is in development. In particular, the timely preparation of translations of computer 10 programs is advanced if translations (*i.e.*, the preparation of versions of the source program for users of a target natural language) proceed in parallel with development of the source program, and prior to finalization of the source program. Therefore, the invention disclosed herein provides a system and a method by which the translation process can be managed efficiently to obtain translated text, and a system and a method 15 that are capable of providing metrics regarding translation tasks that remain to be completed to assist in the allocation of workloads.

With reference now to **Fig. 3A**, the development of a source computer program and of translations of that source computer program into various target languages is illustrated. Initially, a production copy of the source computer program 304 is developed. 20 From the production copy of the source computer program 304, production copies 308 of translations of the source computer program into various target languages are prepared. According to the present invention, the preparation of production copies of translations

308 of the source computer program may be initiated prior to the development of a finalized copy of the source program 312. Accordingly, as the production copy of the source computer program 304 evolves in the development process, the production copies of the translations 308 of the source program must be revised to track the changes to the 5 production copy of the source program 304. After development of the production copy of the source program 304 is complete, a finalized or master copy of the source program 312 may be released to end users. Similarly, when production copies of the translations 308 of the source program are complete, finalized copies of the translations 316 can be released to end users. In **Fig. 3A**, translations of the source computer program 304 into 10 three different target languages are illustrated. Of course, a greater or lesser number of translations may be prepared in connection with the present invention. As an example of typical natural languages involved in such a translation process, the source computer program 304 may be prepared using English, while the first target language used in connection with the preparation of the first translation 308a and the finalized copy of the 15 first translation 316a may be Spanish. As a further example, the second target language 316b may be German, and the third 316c Japanese.

With reference now to Fig. 3B, an arrangement of data in accordance with an embodiment of the present invention is illustrated. In general, the translation of natural language portions of computer program text into natural languages other than the source natural language is a time consuming, resource intensive process. The task of translating a computer program from a source natural language into a number of different target natural languages can be made more manageable by prioritizing the desired translations.

For example, languages other than the source language used in major markets for the computer program can be assigned to a first tier **304** of languages. In general, target natural languages included in the first tier have translation resources allocated to them so that translations of the source computer program into those target natural languages are

5 obtained relatively quickly. For example, in accordance with an embodiment of the present invention, translations of textual portions of the computer program into tier one **320** languages are scheduled to be available when the finalized version **312** of the source computer program, containing text portions in the source natural language, is available.

Target languages of lesser importance than those assigned to tier one **320** status may be 10 assigned. For example, it may be desirable to eventually provide a translation of a computer program into some additional languages. However, the market importance of versions of the computer program in those languages may still be relatively small.

Therefore, the deployment of translations into such languages is of lesser importance. Accordingly, such languages may be assigned tier two **324** or tier three **328** status. Of 15 course, a lesser or greater number of tiers may be established, depending on the translation needs and schedule associated with a particular computer program. For instance, different tiers need not be established if the translations of a source computer program are scheduled to be released at the same time or if the number of target languages (*i.e.*, the number of translations that need to be prepared) is small.

20 Although the division of translation tasks into categories of importance, as represented by the formation of tiers **320**, **324** and **328** of natural languages, aids in organizing the task of preparing such translations, any translation requires that the source

text first be generated. However, as can be appreciated by one of skill in the art, the generation of source text in a computer program is an iterative, evolutionary process. Accordingly, natural text portions of computer programs are typically fluid, and can change up until the last moment before a finalized or mastered version of the source computer program is released to end users. Accordingly, a system for providing translations of such text should be capable of ensuring that complete translations of the source text into one or more target languages are available at about the same time that the source, or original, version of the computer program is available to end users.

Furthermore, although the importance of translations into different target languages can be prioritized, and those languages having a higher priority can be given greater resources for completing a translation, it can be appreciated that allocating the resources required for preparing translations into different target languages may involve assigning a relatively large number of translators to prepare the translation of a computer program into a first, tier one, target language, and a relatively small number to the translation of a source program into a second, tier two, target language. Accordingly, it can be appreciated that the translation of a source computer program into target languages often requires managing parallel processes that proceed at different rates.

Discrete portions of natural language text for use in connection with a computer program may be stored as text records. In general, for each source language text record, a corresponding target language text record is generated for each target language.

Therefore, in addition to managing translation tasks that proceed in parallel with development of a source computer program, the efficient administration of translation

tasks requires that the status of large numbers of text records be tracked. This task can be further complicated if the different versions of a computer program (*i.e.* the source version and various target versions) are implemented using different code sets. For example, an English language source program will typically be implemented using a 5 different code set than is used to implement a Japanese language target version of the computer program. Therefore, as illustrated in **Fig. 3B**, tiers of languages **320**, **324** and **328** may be further divided into different code pages **332** to **352**. In addition, the source computer program **304**, **312** may be stored in a dedicated code page **356**. Thus, the accurate tracking of translation tasks requires that the status of records stored utilizing 10 different code pages be tracked. The division of text into different code pages facilitates the production of translated computer programs that are defect free, by removing the need to convert the code from one version to another. Therefore, although the use of different code pages **332**-**352** complicates the administration of translation tasks, it generally results in fewer errors in the computer code used to implement the different language 15 versions of the computer program. Of course, the division of the source computer program and translations of the source program among different code pages **332**-**356** is not necessary. For example, in accordance with another embodiment of the present invention a single code page is used in connection with the source computer program and the translations of that program.

20 With reference now to **Fig. 4**, the contents of the data base **116** used to store various information utilized by a system in accordance with an embodiment of the present invention is illustrated. In general, and as can be understood by one of ordinary

skill in the art, the database **116** may be implemented on or in connection with one or more computers **104**, **108** included in the system **100**. For example, and as shown in Fig. **1**, the database **116** may be stored in the program storage/data or memory **208** associated with a server computer **104**.

5 The database **116** includes a production copy of the source computer program **304**. The production copy **304** of the source computer program is used by the developers of the original or source computer program as the working copy of that program. Accordingly, work in developing the source computer program, including changes to the look and feel of that program, are completed in connection with the production copy **304**.

10 Furthermore, development of the source computer program may be performed in connection with a development application **120**.

 The compare copy of the source program **408** is used in connection with the development of translations of the source computer program into one or more target languages. For example, if the source computer program **304** includes English language text, that text may be translated into German, French, Spanish and Japanese. In general, the compare copy of the source program **408** is generated or updated from time to time by copying the then current version of the production copy of the source program **304**.

 The status table **416** established for each translation into a target language contains information related to the status of records of source text included as part of the compare copy of the source program **408**. For example, the status tables **416** may include information regarding events concerning records such as the date that a record in the current compare copy of the source computer program **408** was created and the date on

which that record was most recently edited, if any. In general, the status tables **416** are updated each time a new compare copy of the source computer program **408** is generated.

The status tables **416** also store information related to the corresponding translation of the compare copy of the source program **408** into a target language.

- 5 Accordingly, the target 1 status table **416a** contains information regarding the status of the translation of the source program into a first target language. Similarly, the second status table **416b** contains information related to the status of the translation of the source program into the second target language. In general, during a comparison or delta process, the production copy **304** is compared to the current compare copy of the source computer program **408**, and the status records **416** are updated as a result of the comparison. Accordingly, the information contained in the status tables **416** is related to at least the most recent addition or revision of the text contained in each record of natural language text included in the compare copy of the source computer program **408**. In addition, the information in each status table **416** relates to the status of the translation of 10 the records of natural language text included in the current compare copy of the source computer program **408** into the corresponding target language. In particular, the status tables **416** each contain information regarding whether particular records in the current compare copy of the source computer program **408** have been translated into the relevant target language, and whether the records in the compare copy **408** have been revised 15 since any translation of the record into the relevant target language.
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The database **116** additionally includes production copies of the translated computer program **308**. In general, a production copy of the translated computer

program is maintained for each target language. The production copies of the translations of the computer programs 308, in addition to the translated natural language text, include copies of any programming code associated with the records containing natural language text. This facilitates the preparation of finalized copies of the translated computer 5 program 316, as it removes the need to perform conversions of data before the translated computer program can be released to end users as a finalized version 316. Accordingly, a source of errors that may be introduced in the creation of translated computer programs has been removed by the present invention.

With reference now to **Fig. 5**, a flow chart illustrating the development of 10 translated computer programs in accordance with an embodiment of the present invention is illustrated. Initially, at step 500, source program text is developed as part of a source computer program. A first copy of this source program text is stored as a production copy 304 of the computer program, and a second copy of the source program text is stored as a compare copy 408. At step 504, the existing source program text is edited, 15 and additional source computer program text may be developed.

At step 508, the compare copy 408 of the source program text may be translated into one or more target languages to produce a target language production copy 308 of the computer program. Accordingly, development of the production copy of the source computer program 304 may proceed in parallel with translation of the current iteration of 20 the compare copy 408 of the source computer program. In **Fig. 5**, the compare copy 408 of the source program text is illustrated as being translated into first (at step 508a) and second (at step 508b) target languages. Of course, as can be appreciated by one of skill

in the art, the present invention may be utilized in connection with the translation of the textual portions of a computer program from a source language to a single target language, or to more than two target languages.

In general, until a decision is made to update the status tables **416**, developers

5 may continue to edit the existing source program (step **504**). However, from time to time, it is desirable to run a compare or delta process to update the status tables **416** and to provide an updated compare copy **408** of the source computer program from which translators preparing translations of the source computer program into a target language can work. Updates of the status tables **416** may be performed periodically, according to a

10 predetermined schedule, or in response to changes in the status of the development process. For example, early in a development cycle, when the addition of large numbers of records containing natural language text requiring translation can be expected, the update of the status tables **416** can be performed relatively infrequently (e.g., every two weeks). Later on in the development cycle, as development shifts more towards revisions

15 of existing records, updates of the status tables **416** may be performed more frequently (e.g., once a week). Furthermore, it can be appreciated that updates may be performed at different time intervals depending on the work load of the translators. For example, when a large number of existing records of natural language text require translation, there is generally less impetus to devote system resources to updating the status tables **416**.

20 However, as the number of records containing natural language text requiring translation is reduced, there is more impetus to update the status tables **416**.

After a decision to update the status records has been made at step **512**, the status tables **416** are updated, and the compare copy **408** of the source computer program text is set equal to the current production copy **304** of the source computer program text (step **516**).

5 In **Fig. 5**, step **524** regarding the decision to update the status tables **416** corresponds to step **512**. That is, step **512** shows the relationship of the step of running the compare process to the other steps involved in the development of the source program text, while step **524** shows the relationship of the step of running the compare process to the other steps involved in the development of translated versions of the computer program. Accordingly, until the decision to update the status tables **416** is made, the translation process or processes remain at step **508**. Upon a decision to update the status tables **416**, the status of each record in the production copy **308** of each target language translation is updated (step **528**). Also at step **528**, the compare copy **408** of the source computer program text is updated to equal the current production copy of the source computer program **304** text. Accordingly, step **528** corresponds to step **516**, and shows the step of updating the status tables **416** and the compare copy **408** of the source computer text in the context of developing translations of the first computer program.

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 Returning to consideration of the development of the source computer program in the source natural language, at step **536**, a determination is made as to whether the current production copy of the source computer program text is a final version. If not, the development of the source computer program continues at step **504**. If the current production copy of the source computer program text is to be released as a finalized

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version, then the development of a source program text is complete (step 540). Of course, development of follow-on versions of the source program text may continue, as can be appreciated by one of skill in the art.

With respect to the translations of the natural language text records included in

- 5 the source program, if the updated compare copy received following an update of the status records is not a finalized version (step 544), translation of the updated compare copy proceeds at step 508. If at step 544 it is determined that the updated compare copy of the text in the source computer program represents a finalized version, a determination is next made as to whether any records of natural language text included in the source
- 10 computer program remain to be translated into the relevant target language (step 548). If records remain to be translated, then the translation of the records containing natural language text into the relevant target language is finalized (step 552). After finalization of the translation at step 552, or after determining at step 548 that no records containing natural language text remain to be translated, the translation into the relevant target
- 15 language is complete (step 556).

With reference now to **Fig. 6**, a translation application 124 included as part of a translation tools system 122, such as may be run in connection with a client computer (e.g., client computer 108b in **Fig. 1**) is shown operatively connected to a database 116 (e.g., operating on a server computer 104 in **Fig. 1**). In general, the translation

- 20 application 124 performs functions to assist a translator in translating records of natural language text from a source language to a target language. Accordingly, the functions of the translation application 124 may include a search engine 604, for displaying a selected

set or sets of records to the translator; a suggestion engine **608** for providing suggested translations of natural language text; a status table update engine **612** for updating the relevant status table **416** in response to actions performed by the translator in connection with the translation application **124**; a user interface **616** for receiving commands and data from the translator; and a display engine **620** for displaying information to the translator, including records containing natural language text.

It should be understood that **Fig. 6** includes illustrations of basic functions that may be performed by the translation application, and that such illustration is not exhaustive of the functions capable of being performed by the translation application **124**.

Using the translation application **124**, a translator may access various information. For example, the translator may view records containing natural language text having a selected status. The translator may also choose to view summaries of selected data, including records and information regarding the number of records included in a selected category, and the status of those records. The translation tools application **124** also allows a user to view the contents of a selected record, and allows a translator to view the contents of a selected record in the context of the computer program. The translation application **124** may also be used to provide a display of record statistics and metrics, such as the number of records having a particular status.

With reference now to **Fig. 7**, a flow chart illustrating the operation of a translation application **124** in accordance with an embodiment of the present invention is illustrated. Initially, at step **700**, the translation application **124** is opened. Next, at step

704, the user or translator may select processing options. The translator may next select the type of text to work with, such as text from a particular source or form (step 708).

At step 712, the translator may use the translation application 124 to search within a selected text source type for records related to a selected target language and having a selected status. Accordingly, it should be appreciated that the translation tools application 124 may provide a front end interface that can be used by translators responsible for translating the source text into different natural languages. From the search results returned, the translator may select an individual record for translation, editing or review (step 716). Accordingly, it should be appreciated that the search 5 performed at the direction of the translator may return results that include records that have already been translated for editing and/or review. Translation of the text, or edits to the text, or approval of a previous translation or suggested translation, may next be 10 performed (step 720).

The translator can, at step 724, decide to reject the translation of the record, and 15 flag the record for further review (step 728). Alternatively, the translator can accept the translation (step 724). In response to an indication that the translator has accepted the translation or after the record has been flagged for review, the translation application 124 updates the status table 416 for the relevant target language (step 732).

The translator may then choose to navigate to another record of the same selected 20 type, status and target language (step 736) by selecting a next individual record (step 716). Alternatively, a search for records having a different target language and/or status may be performed (step 740) by performing a new search (step 712). As still a further

alternative, the translator may select a different type of text to work with (step 744) by selecting a new text type (step 708). The translator may also exit the translation application 124 (step 748).

With reference now to **Figs. 8-38**, the use of a translation tools system 122 and in particular the use of a translation application 124 in accordance with an embodiment of the present invention to perform example translation tasks is illustrated. Initially, after logging onto a computer (e.g., computer 108b in **Fig. 1**), the user may select the translation tools 122, in which case the user or translator is presented with a translation tools selection screen 800. From the translation tools selection screen 800, the translator may select from translation applications 124, delta or compare process administration 808, and delta or compare process environment administration 812.

With reference now to **Fig. 9**, if the translator selects the delta environment administration item 812, various submenu items are displayed in the tree view window 802. In general, the submenu items that may be selected under the delta environment administration item 812 allow an administrator to configure various aspects of the environment in which the translation process and the development of target programs will proceed. For example, an administrator may use selections under the delta environment administration 812 item to configure the code pages 332-352 (see **Fig. 3B**) that will be used in connection with various target languages.

The delta process administration selection 808 includes submenu items that allow an administrator to control aspects of the delta or compare process (see **Fig. 10**). For instance, the delta process administration 808 item provides submenu selections 1004 to

initiate the compare or delta process. In addition, a purge and rebuild program **1008** allows an administrator to remove invalid records and rebuild records that have been deleted inadvertently. A content manager application **1012** allows for changes in the source program to be tracked. This feature is useful in performing functions other than preparing translations of source text, such as preparing documentation related to the operation of the source computer program.

As shown in Fig. 11, the translation application 124 may be accessed by various categories of translators. For example, senior translators may utilize a first translation application 124a (item 1104), while junior translators may utilize a second translation application 124b (item 1108). In general, the differences between the translation application 124a utilized by senior translators, and the translation application 124b utilized by junior translators includes the actions that may be taken with respect to a record. Furthermore, it should be appreciated that the translation applications 124a-b accessed through the different menu items 1104, 1108 may be identical, except that certain options may have different default values. The particular translation application 124 utilized by a translator may result in records being assigned different statuses. For instance, a record may be assigned a "review" status after a translation of source text has been entered by a junior translator, indicating that the translation should be reviewed by a more senior translator. A record may be assigned a "complete" status after it has been translated by a senior translator, or after a previously completed translation has been reviewed by the senior translator. The status assigned to a record after review may, according to an embodiment of the present invention, be entered in the relevant status

table 416 automatically, after the translator has selected a next record for review.

Accordingly, the present invention assists translators in efficiently performing their duties.

With reference now to Fig. 12, a translation application language master screen

5 1200 is illustrated. The language master screen 120 may be selected from a submenu
item 1016 (see Fig. 10) under the delta or compare process administration item 808 in the
translation tools screen 800. The language master screen 1200 includes a language
column 1204 containing a target language code for each target language that the source
computer program is being translated into. A code page column 1208 indicates the code
10 page 332-352 associated with the language 1204. A second code page column 1212
includes links that allow the administrator to connect to a code page from the language
master screen 1200. An MS Word language I.D. column 1216 contains the language
code for each of the languages 1204. By associating the MS Word language I.D. 1216
with the target language 1204, the translation application 124 may provide spell check
15 functionality in the target language 1204 to assist translators in preparing accurate
translations. This spell check functionality in the target language may be provided even
though the translation application 124 is written in the source language. In addition,
language load 1220 and effective from 1224 columns are provided to assist the
administrator in determining when the code page environments were established.
20 With reference now to Fig. 13, a work with delta table inclusions page 1300 is
illustrated. The work with delta inclusion page 1300 may be selected from a submenu
item 1010 under the delta process administration 808 menu heading (see Fig. 10). In

general, the work with delta table inclusions page 1300 allows an administrator to confirm that the compare process is proceeding as expected. In a description column 1304, descriptions of different sources of natural language text included in a source computer program are listed. The associated delta table code 1308 for each of the 5 sources in the description column 1304 is also shown. The include table column 1312 allows the administrator to determine which of the sources of natural language text are included in a particular compare process. The selective inclusion of tables in which natural language text may be found is useful in limiting the amount of resources required to run the compare process. In addition, the version column 1316 allows compare 10 process tasks to be assigned to different computers 104, 108 to allow for the efficient allocation of those computing tasks.

The status description column 1320 includes an indication of whether the compare process was successful with respect to each of the tables for which the compare process was run. A total records column 1324 displays the total number of records from 15 a given source 1304, and a change records column 1328 indicates the number of those records included in the total records that have been changed since the last compare process was run.

With reference now to Fig. 14, a processing options window 1400 is illustrated. The processing options window 1400 allows various options to be selected for 20 automating the translation process. For example, a translation filter status 1404 may be entered so that only those records having the selected status are returned to the translator associated with the processing options 1400. A translated status selection 1408 allows

the administrator to determine what status is entered with respect to a record after that translator has reviewed or edited a record containing natural language text. The review status **1412** selects the status that is associated with a record after the translator has reviewed the record, but not altered the translated text of the record. A skip reason status

5 **1416** is the status that is associated with a record after a translator has skipped a particular window without translating the text associated with the record. Accordingly, it can be appreciated that the processing options are selected prior to performing translations in connection with the translation application **124**. In addition, it can be appreciated that separate processing options may be maintained and determined by the administrator.

10 With reference now to **Fig. 15**, a processing options window **1500** is illustrated.

The processing options are associated with each application, and allow the administrator to select aspects of the operation of the translation application **124** that will apply when the translator is utilizing the translation application **124**. Accordingly, the translator may use the processing options window **1500** to select whether MS Word spell checking is

15 activated by entering the appropriate code in a window **1504**, and to select the local spell checking language in a window **1508**.

With reference now to **Fig. 16**, a translation tools view window **1600** illustrating various sources **1602** of natural language text records associated with a source computer program is illustrated. As can be appreciated, the sources listed in the translation tools window will vary depending on the particular application or set of applications (*i.e.*, system) that comprises the computer program being translated. In order to begin translation, a translator may select one of the sources.

In Fig. 17, an example of a screen displayed to a user after selecting a particular source of natural language text records is illustrated. In the present example, the Forms Design Aid item 1604 (see Fig. 16) was selected, and thus a work with forms design aid text window 1700 is presented to the translator. In general, the "work with text" window 5 1700 provides a front end to search capabilities provided by the translation application 124. In particular, a number of search criteria 1704 may be specified by a translator.

These search criteria 1704 may include the product code 1708, for specifying the particular source computer program in connection with which records containing text for translation will be performed. In general, selection of a source of text in the translation

10 tools window 1600 (see Fig. 16) results in a "work with" window being presented to the translator. A status window 1712 is provided to allow the translator to specify a search for records having a particular status. In the example window 1700 shown in Fig. 17, the entered status 11 is a "complete" status defaulted from the processing options 1400 (see Fig. 14). Accordingly, the returned records from this example search will all have a 15 status of "complete". A language window 1716 defaulted from user profile setup allows the translator to search for records with reference to a particular target natural language.

Accordingly, records returned from the search will be related a translation of the source computer program into the specified target language. In the example shown in

Fig. 17, the target natural language is Spanish, specified by the code letter "S". A status

20 details check box 1720 is provided to allow the translator to have a list of individual records returned as a result of the search. The search results window 1724 contains information regarding the results of the search.

In the example of **Fig. 17**, the status details box **1720** has not been checked.

Accordingly, the search results are organized according to the form name **1728** with which individual records are associated. A record count column **1732** lists the number of individual records associated with each form. The status column **1736** shows the status 5 of the records returned in connection with the search. Here, because the search criteria for a status **1712** was specified as "complete" using code 11, all of the records found as a result of the search have a status of 11. Similarly, all of the returned records are related to product code 01 **1724**, as product code 01 was specified as part of the search criteria **1708**. If the translator had checked the status details box **1720**, information related to 10 each individual record complying with the search criteria **1704** would be listed, rather than having the records grouped according to their form name **1728**.

With reference now to **Fig. 18**, a select user define code window **1800** is illustrated. The select user define code window **1800** is displayed to the translator following selection of the user defined codes item **1708** from the translation tools 15 window **1700** (see **Fig. 17**). The select user define code window **1800** allows the translator to view assigned codes. Accordingly, the select user define code window **1800** provides the translator with an explanation of what various numeric codes signify in the source computer program **304**.

Fig. 19 illustrates a record view window **1900** in accordance with an embodiment 20 of the present invention. The record view window **1900** allows a user to select particular records for translation. In the example window **1900** shown in **Fig. 19**, and in particular in the record tree display window **1902**, records from form name W01012B are

displayed. According to the present example, this form could have been selected from the listing for that form 1740 in the "work with text" screen 1700. In the example record view window 1900 of Fig. 19, an individual record containing the natural language text word "prefix" in the source computer program is highlighted 1904. On the right side of the bar in the highlighted item 1904, the code "AR1" is displayed in parentheses together with a translation of the natural language text into the target language (Spanish in the present example), "Prefijo". The highlighted natural text record 1904 is part of a larger group of records that belong to object name P01012, as shown in the object name text box 1908. In addition, the displayed records are from form W01012B, as shown in form name box 1912.

In addition to displaying the natural language text contained in the selected record in the record tree display window 1902, a first source text edit box 1916, a second source text edit box 1918, a first target text edit box 1920, and a second target text edit box 1922 are provided. In the record view window 1900, the source text edit box 1916 is disabled, to prevent a translator from altering the source text. The target text edit box 1920 allows the translator to enter a translation of the source text. Alternatively, the translator may use the target text edit box 1920 to edit a previous translation of the source text. The translator is assisted in preparing an accurate translation of the source text by the code displayed with the record 1904. In the present example, the highlighted record 1904 includes the code "AR1". This indicates to the translator that the term prefix relates to accounts receivable. By providing the translator with information regarding the context

in which the natural language text is used, the translator is assisted in preparing an accurate translation of the source text.

The translation application 124 also provides automated features to assist the translator in rapidly preparing translated text. For example, an options area 1924

5 includes various check boxes to allow the translator to make selections regarding navigation, and to selectively enable spell checking of the source text, the target text, or both the source and the target text. All tree views such as **1902** can be displayed with Source, Target or Both types of language text **1926** by making the appropriate selection in the options area **1924**. A proposals area **1928** allows the translator to select whether automated proposals for translations of source text are provided. In the present example, the suggestions check box **1932** is selected. Accordingly, the translator will be provided with a proposed translation if a table of suggestions included as part of the translation application **124** includes a translation of text matching source text displayed in the edit boxes **1916**, **1918**. The translator may also select the data dictionary check box **1936**, in which case a translation of terms included in the data dictionary will be returned, if an appropriate entry in the data dictionary is available. Where a translation is available in both the suggestions and the data dictionary areas, and the translator has enabled proposals from both sources, the data dictionary entry will be provided over the suggested entry.

10 In the example of **Fig. 19**, a status area **1940** displays an icon "suggestion loaded" **1944** to signify that a target edit box **1920**, **1922** contains text that was obtained from the suggestion table. Accordingly, if the translator agrees that the text displayed in the target

edit box 1920, 1922 is an accurate translation of the source text displayed in the source text edit box 1916, 1918 the translation can be completed by clicking the "OK" button 1948. A status window 1952 is provided to allow the translator to assign a selected status for the record associated with this translation. In the present example, the status code 5 "11", signifying that the translation is complete, has been automatically loaded as a result of the entries that were made in the processing options window 1400 (see Fig. 14) with respect to the translator logged into the translation application 124.

The second source text edit box 1918, and the second target text edit box 1922 are provided to display text that is divided into two parts. As an example, the "TAX I.D." 10 record 1964 might display the word "Tax" in the first source text edit box 1916 and the word "I.D." in the second source text edit box 1918. The translator would then enter a translation for the term "Tax" in the first target text edit box 1920, and a translation of the term "I.D." in the second target text edit box 1922.

With reference now to Fig. 20, a forms design aid audit window 2000 is 15 illustrated. The forms design audit window 2000 may be accessed by clicking the audit tab 2004, for example from the forms description record view window 1900. In general, the audit window 2004 displays information related to the overall status of a translation into a target language. Accordingly, in the item count area 2008 a first column of numbers provides information regarding records included as part of a particular form. 20 The form with respect to which this information is provided is the active form, selected from the work with forms design aid text window 1700 (see Fig. 17). In the present example, the selected form continues to be Form W01012B 1740. Thus, from the item

count area **2008**, it is apparent that the selected form **1740** contains one form having various other components. The first column **2012** in the item count area **2008** displays the total number of item types within the selected form. In the present example, the selected form comprises a total of 32 items. The second column **2016** displays the

5 number of items enumerated in the first column **2012** that have a selected status. The currently selected status displayed in the filter status box **2020**. In the present example, the currently selected status **2020** is 11, signifying "complete" in the present example. Nineteen items are shown in the second column **2016** as being "complete". The active status is selected in the status box **1712** included as part of the search criteria **1704**

10 accessible from the work with forms design aid text window **1700** (see Fig. 17). The current record count **1732** reflects the number of records in each form matching the search criteria **1704**. For example, for Form W01012B **1740** there are 19 records **1742** matching the search criteria **1704**.

Various information related to the record being edited, the text of which continues

15 to be displayed in the source text edit box **1916**, **1918** together with any translation of the source text in the target text edit boxes **1920**, **1922** is displayed by the design aid audit window **2000**. In particular, the delta audit area **2024** contains information regarding compare processes run with respect to the active target record. An audit trail area **2028** displays information regarding the last translator to work on the active target record. The

20 translator audit area **2032** displays information regarding the last translator to enter a translation of the active target record and the date of that translation, the times that a

translation has been entered with respect to the source record into the relevant target language, and the code page on which the target record is stored.

As shown in **Fig. 21**, the activation of the tasks tab **2100** displays a forms design aid text tasks window **2104**. The tasks window **2104** is useful in performing quality assurance of the translation. In particular, source text records are shown with any translation of those records into the target language. In addition, information regarding the particular application within the source computer program that each natural text record is associated with, and the system or systems that use that application, are displayed.

As shown in **Fig. 22**, selection of the data dictionary tab **2200** provides a display of a data dictionary window **2204**. The data dictionary window **2204** allows a user to access particular data dictionary items. In the present example, the source text, shown in the source text edit boxes **1916**, **1918** is "phone type". Accordingly, the display in the data dictionary window **2204** displays information regarding where the terms "phone" and "type" appear in connection with a computer program. In addition, a usage display window **2208** shows where the exact term "phone type" is used. In the present example, the data dictionary tree **2204** can be displayed by selecting the data dictionary tab **2200**. Alternatively, where a suggested translation has been provided and the data dictionary default icon **2212** is displayed in the suggestion area **1940**, the data dictionary default icon **2212** may be selected to display the data dictionary window **2900** (see **Fig. 29**).

As shown in **Fig. 23**, a selection of the glossary tab **2300** provides the user with a glossary window **2304**. The glossary window **2304** displays any glossary entry related to

the selected text (*i.e.*, the text displayed in the source text edit boxes 1916, 1918). The glossary entry may be provided in both the source language, and the target language. The glossary entry is useful in assisting a translator in preparing an accurate translation of the selected natural language text record.

5 With reference now to **Fig. 24**, a processing options window 2400 is illustrated. The processing options window may be displayed by selecting the processing options tab 2404. In general, the processing options window 2400 contains text related to a selected application that has been translated into the target language. Accordingly, the processing options window 2400 assists translators and other users in ensuring that an application is
10 completely translated.

As shown in **Fig. 25**, the translation application 124 allows a user to view both source text and translated text in the context in which such text will appear in the finalized computer program. In particular, a target preview window 2500 is provided for displaying a screen of the computer program in which the text of the selected record will
15 appear in the version of the computer program that has been translated into the target language. Alternatively or in addition, a source preview window 2504 may be displayed that contains the text of the selected record in the context of its usage in the source computer program. The target text window 2500 may be displayed by selecting the target preview button 2508, and the source language window 2504 may be displayed by
20 selecting the source preview button 2512. By providing such in-context views of source text and translated text, the translation tools 124 assist translators in preparing accurate translations of text from a source language into a target language.

In addition, the in-context view capability illustrated in **Fig. 25** is dynamic.

Accordingly, if a translator, for example, edits a previous translation of a term, and then selects the target preview while the relevant record is selected, the target application window **2500** displayed will incorporate the most recent edit of the translation.

5 As shown in **Fig. 26**, a suggested translation can be displayed in a suggestion window **2600**. In general, the suggestion window **2600** can be accessed by selecting the suggestion icon **1944** (see **Fig. 19**). Accordingly, whenever a suggested translation is available, the translator may access detailed information regarding the suggestion by activating the suggestion window **2600**. The information includes a description of the

10 source record and the target. In addition, a product code may be provided if available. In addition, a source search text edit box **2604** may be provided to allow the translator to alter the search that is performed. In general, as shown in the example of **Fig. 26**, a search for the selected text in the source language is conducted when the suggestion window **2600** is selected, with any characters on either side of that text. Furthermore, the

15 translator may select the target language into which the selected text is to be translated by entering the appropriate language code in language code box **2608**. The product code may also be specified in product code box **2612**.

As shown in **Fig. 27**, the translation application **124** provides spell checking capabilities in the target language. In accordance with an embodiment of the present invention, a spell check of text entered in the target text edit box **1920**, **1922** can be spell checked by selecting a button **2704**. Alternatively, the spell check function can be activated when the user selects the OK button **1948** if spell checking is activated in the

processing options (see **Fig. 15**) for the user. If the spell check detects an error, a spell check window **2708** is displayed that allows the user to select a suggested alternative to the text entered by the user, or to ignore the suggestion. It should be appreciated that the spell check is provided for the target text entered in the target text edit boxes **1920** and **1922** (if any) in the target language, even though the translation application **124** itself uses a different language (*e.g.*, the same language as the source program being translated). Accordingly, the translation application **124** accesses spell check libraries relevant to the activated target language.

5 In **Fig. 28**, an example of menu items available to a user of the translation application **124** is shown. In particular, **Fig. 28** illustrates that various translation tools may be accessed through menus. For example, the data dictionary may be accessed by selecting the DD menu item **2804**, by selecting the DD icon **2212** (see **Fig. 22**), by selecting the DD tree **2204** (see **Fig. 22**), or by selecting the DD button **2808** in the form bar **2812**.

10 In **Fig. 29**, a data dictionary translation window **2900** is illustrated. The data dictionary translation window **2900** allows a user to search for entries in the data dictionary by entering a description of the text for which information is sought in an alpha description window **2904**. Any entries in the data dictionary related to the text entered in the alpha description box **2904** can be shown in the source language, the target language, or both the source and target language by selecting the appropriate option **2908**.

With reference now to **Fig. 30**, a data dictionary translation window with the glossary tab selected **3000** is illustrated. With the glossary tab **3004** selected, the glossary entry found in connection with the search term entered in the alpha description text box **2904** (see **Fig. 29**) is shown together with the source text version of the glossary entry. In 5 addition, the source text and the target text are shown in edit boxes **3008**, **3012** so that the glossary entries can be edited.

In **Fig. 31**, a data dictionary translation screen **3100** with the audit tab **3104** selected is illustrated. In general, the audit information includes information regarding when items were last translated and how many times compare functions have been run 10 with respect to those data dictionary items.

In **Fig. 32**, a data dictionary translation window **3200** with the status tab **3204** selected is illustrated. The information provided by this window **3200** assists translators and administrators in determining how many records remain to be translated and/or reviewed for the current product code **3206**. Such information is useful in determining 15 further workloads and translation schedules.

In **Fig. 33**, various methods of navigating to user defined codes (UDCs) are illustrated. For example, the UDC menu item **3304** may be selected. Alternatively, the UDC information may be edited by selecting particular instances of that information in the tree view window **3308**. User defined codes may additionally be accessed by 20 selecting the UDC button **3312**. Accordingly, it should be appreciated that the translation application **124** allows a translator to search for records of a particular type, for example when problems with such records have been detected. Thus, in addition to allowing

searches for records having a particular status, groups of records may be returned in response to searches that do not require the records to have a particular status.

In **Fig. 34**, a user defined codes translation window **3400** is illustrated. In general, the user defined codes translation window **3400** may be accessed in any of the ways 5 described above in connection with **Fig. 33**. Target text included in the user defined codes may be edited in the target text edit box **3404**.

In **Fig. 35**, a search and replace window **3500** is illustrated. The search and replace window allows a translator to search for records containing source text by specifying various criteria. Such criteria may include the product code **3504** with which 10 the desired record is associated, the status of the records **3508**, the target language **3512**, the last translator **3516**, and the dates of translation **3520**. The source text, target text and other information concerning records returned as a result of the search are displayed in the results window **3504**.

In **Fig. 36**, a search and replace application window **3600** is illustrated. In general, the search and replace application window **3600** provides different types of 15 search terms with which records can be searched as compared to the general search and replace window **3500**.

With reference now to **Fig. 37**, a search and replace search text window **3700** is illustrated. The search and replace search text window **3700** provides a source text entry 20 box **3704** and a target text entry box **3708** in which text that is to be searched for can be entered. As shown in **Fig. 37**, the entered text may include wild card characters. In addition, selections regarding the primary search **3712** and secondary search **3716** options

can be selected. For example, the primary search options **3712** include a choice of either the source records or target text records. This allows significant flexibility in configuring the search. For example, as shown in **Fig. 37**, when the source text records are selected in the primary search options **3712**, those records containing the word "address" (*i.e.* the term entered in the source text data box **3704**) will be found. Then, from among those records containing the word "address", records having the target text "direc" will be returned. The capability to perform tiered searches is especially useful in searching for records having known errors.

5 In **Fig. 38**, a search and replace find and replace window **3800** is illustrated.

10 Using the find and replace window **3800**, a translator may find records containing selected target language text, entered using the find edit box **3804** and replace that text with text entered in the replace with edit box **3808**. Accordingly, the task of, for example, finding known errors in records and substituting corrected target text can be automated.

15 From the above description, it is apparent that the present invention facilitates the translation of natural language text from a source language to one or more target languages. In particular, the present invention allows translations to be performed in parallel with development of the computer program from which the source text is derived. In addition to allowing such parallel development, the present invention provides information regarding the status of a translation into a target language, assisting in the efficient allocation of tasks, and in the accurate estimation of work loads.

20 Furthermore, the present invention provides an interface that allows translators and

administrators to easily manipulate records and obtain data regarding the translation process from a number of discrete but interrelated tables.

In addition to the organization structure and status information provided by the present invention, the task of translating text is facilitated by the present invention. In particular, translators are provided with the source text and their translation of the text, or a previous or suggested translation of the source text, simultaneously. Accordingly, translators need not change between different screens in order to view the source text and a translation of the text. In addition, by selectively providing suggested translations, the need for a translator to manually type in translations is reduced. Furthermore, the present invention allows both source text and text translated into a target language to be displayed, either alone or simultaneously. Such "in-context" views assist translators in preparing translations.

The present invention also allows translators to navigate among records containing natural language text in a variety of ways. Therefore, translators can merely 15 define groups of records, and then select individual records from defined groups for translation or review. Information related to the status of individual records can be entered automatically in connection with the translation, again reducing the workload on the translator and facilitating the timely development of translated programs.

Although the description of the present invention has largely been in terms of translating text from a source language into one or more target languages, the present invention is not so limited. For example, the status information provided by the present invention is useful in connection with the proofing of source text contained in records. In

addition, the present invention is useful in connection with the development of documentation concerning the source computer program.

The foregoing discussion of the invention has been presented for purposes of illustration and description. Further, the description is not intended to limit the invention to the form disclosed herein. Consequently, variations and modifications commensurate with the above teachings, within the skill and knowledge of the relevant art, are within the scope of the present invention. The embodiments described hereinabove are further intended to explain the best mode presently known of practicing the invention and to enable others skilled in the art to utilize the invention in such or in other embodiments and with various modifications required by their particular application or use of the invention. It is intended that the appended claims be construed to include the alternative embodiments to the extent permitted by the prior art.